Docket No. F-7859

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Junichi ISHIZUKA
Serial No.	:	10/619,103
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For	:	MOLDING METHOD OF MICROLENS ARRAY AND MOLDING APPARATUS OF THE SAME
Group Art Unit	:	1731
Examiner	:	Queenie S. Dehghan
Confirmation No.	:	5800
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DECLARATION UNDER 37 C.F.R § 1.132

I, Junichi ISHIZUKA, hereby declare the following:

I am a citizen of Japan and I reside at 5-13-2, Motobuto, Urawa-ku, Saitama-shi, Saitama, Japan.

I am the inventor of the above-identified patent application.

My educational background is in materials engineering at Tolyo Institute of Technology.

I have been working in the field of materials engineering for 10 years.

I am currently employed in developing manufacturing techniques fo- glass molding.

I am familiar with U.S. Patent Application No. 10/619,103 and the following references cited in the rejections of the claims: U.S. Patent No. 6,305,194 (Budinski et al.) and JP 60-171234 (Shimizu et al.).

Comparison of the invention of U.S. Patent Application No. 10/619,103 and Budinski et al.

Budinski et al. is directed to a method for molding microlens arrays. In Budinski et al., Figure 5 shows the apparatus used for the molding and Figure 7 shows the molding itself. It is clear from Figures 5 and 7 that the preform 114 is not restricted by a restrictor as disclosed in U.S. Patent Application No. 10/619,103 ("'103 application"). In Figure 2, the '103 application discloses a molding apparatus where the glass material is not restricted and in Figures 3 and 4 discloses the middle plate 4 restricting the flow of the glass material. The arrangement of Figures 3 and 4 of the '103 application provides improved results relative to the apparatus shown in Figure 2. I am aware of the disclosure in Budinski et al. on page 4, lines 62-64 which states that the microlens arrays are free from surface figure distortion. The extent to which rheological parameters such as viscosity or other variables help improve performance in the invention of Budinski et al. will not be discussed in depth in the present Declaration. It is sufficient to state that the '103 application provides improved results with the restriction of the glass material as opposed to no restriction of the glass material.

Discussion of Shimizu et al.

Shimizu et al. is directed to a glass lens molding device in which the lenses are biconvex lenses, as made clear in the Figures and from the paragraph bridging pages 2-3 of the English translation. An objective of Shimizu et al. is to prevent the lens surfaces from being inclined. This is accomplished by utilizing slide core portions 3R and 3L to keep the dies positioned so as to avoid the inclination of the lens surfaces.

In Shimizu et al., the Figures indicate a lower die being wider than an upper die, the glass lens being formed between the lower die and the upper die. Shimizu et al. does not disclose that having the lower die be wider than the upper die will reduce the inclination of the molding surfaces.

Discussion of and Comparison Between Shimizu et al. and Budinski et al.

Heating

Budinski et al. is directed to induction heating with induction heating coil 116[1]. Fig. 5 of Budinski et al. shows the molds with an induction heating coil 116 around them and Budinski et al. discloses in column 4, lines 38-42 and lines 53-61 that induction heating is utilized for heating and that a mold body is preferably positioned surrounding the mold halves.

The sliding core parts 3L' and 3R' (or sliding core parts 3L and 3R) are positioned 360 degrees around the molding equipment in Shimizu et al., as is clear from the Figures of Shimizu et al. Additionally, the sliding core parts are advanced and retracted by cylinders 4. The position

[1]Other heating methods are disclosed, but Budinski et al. is primarily directed to induction heating, which is an expeditious way to perform the heating.

of the Office Action of December 12, 2007 ("Office Action") is that the sliding core parts 3L' and 3R' as well as the cylinder 4, which is necessary to move sliding core parts 3L' and 3R', can be added to the invention of Budinski et al. However, adding such comparatively large structures would interfere with the positioning of the heating coils, particularly since the sliding core parts substantially laterally enclose the area around the molding material. Additionally, such comparatively large pieces and their associated mechanisms of motion (c.g., cylinders 4) would also interfere with the positioning of the mold body that is preferably around the mold halves. Accordingly, adding the sliding core parts 3L and 3R' as well as cylinder 4 to the invention of Budinski et al. would significantly interfere with the heating of the mold apparatus of Budinski et al.

Amount of Glass Molding Material Used

The Figures of Shimizu et al. show the glass molding material extending to the sliding core parts and accumulating in the circular space portion 5A or concave portion space 5B.

There is no indication that any excess glass material is utilized in the invention of Budinski et al. Moreover, the disclosure of Budinski et al. teaches that such a situation would be detrimental for the invention of Budinski et al. In column 6, lines 42-67 is a rheological explanation regarding the invention of Budinski et al., where it is disclosed that Equation 2 can be used to estimate the load and viscosity required to achieve a specific mold compression rates. Budinski et al. states that if the glass flows too quickly that the glass will not completely expel gas from the microlens cavities. It is also clear from Budinski et al. (see Equation 1) that for any specific mold compression rates, that the increase in the volume of the glass preform will

increase the velocity of the glass front during molding. Accordingly, for any specific mold compression rates, Budinski et al. teaches that the volume of the glass preform cannot be too high since this will increase the velocity of flow of the glass front during molding which will adversely affect the removal of gas from the microlens cavities. Accordingly, Budinski et al. teaches that using too much glass material will result in diminished quality lenses.

Inclination of Lens Surfaces

Shimizu et al. discloses avoidance of inclination of lens surfaces by using slide core portions. There is no disclosure in Budinski et al. that there is an inclination problem with the lens surfaces. Moreover, Shimizu et al. is directed to forming single lenses while Budinski et al. is directed to forming microlens arrays, which means that having a lens surface inclination problem in Shimizu et al. does not necessarily mean that such lens surface nclination problem is also present in Shimizu et al. Moreover, the statement in column 4, lines 62-64 of Budinski et al. that the microlens arrays "are free from surface figure distortion" would indicate to one of ordinary skill in the art that there is no inclination problem with the lens surfaces in the invention of Budinski et al.

Shape of Lenses

Shimizu et al. discloses that Figure 6 shows ideal lens 20. In other words, Shimizu et al. teaches that the ideal shape for a lens is as shown in Figure 6. In contrast, F gure 5 of Shimizu et al. shows a shape of a lens that is not ideal since it includes an additional shape caused by the circular space portion 5A. Similarly, the inclusion of a concave portion space 5B would also

provide a lens which is not ideal. Thus, the lenses created by the invention of Shimizu et al. are not ideal. The optical performance of the portions of the lens where additional shapes are created by the sliding core parts of Shimizu et al. will be different than if the additional shapes are not created and therefore the presence of the sliding core parts will adversely affect the optical performance of the peripheral portions of the lens by creating a lens which does not have an ideal shape. If the sliding core parts of Shimizu et al. are used in the invention of Budinski et al. and there is, hypothetically, sufficient glass material to create the additional shapes mentioned above, then the peripheral portions of the microlens array, where the additional shapes are created, would have adverse optical performance relative to other locations on the microlens array. Accordingly, including the sliding core parts of Shimizu et al. in the invention of Budinski et al. such that additional shapes are created in the periphery of the microlens array of the invention of Budinski et al. will result in the optical performance of lens elements of a central area and a peripheral area of the microlens array to not be homogenized.

Also, the invention of Shimizu et al. is configured such that excess material flows into circular space portion 5A or concave portion space 5B. Thus, the availability of, for example, circular space portion 5A or concave portion space 5B creates a situation where the pressure exerted in the peripheral areas of the glass material is lower than a pressure exerted in the center of the glass material. This is caused because the material is merely being channeled to circular space portion 5A or concave portion space 5B as overflow. Therefore, the transfer performance on the peripheral sections would be less than in a central area because of this pressure differential. The modification of Budinski et al. to include the sliding core parts of Shimizu et al. will also result in a difference in transfer performance in a central area versus peripheral areas of the glass

material even if excess glass material is used since the glass material would be channeled to overflow sections and therefore result in a pressure differential between the center and periphery of the lens material. This difference in transfer performance will result in a difference in the optical characteristics of the peripheral lenses versus lenses in a central portion of the lens array.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date April 7, 2008

By Junichi Ishizuka

Junichi ISHIZUKA

English translation of Shimizu et al.

Specification

1. Title of the Invention
GLASS LENS MOLDING DEVICE

2. Claims for the Patent
(1) A glass lens molding device, characterized by comprising:
a molding die for pressing and molding a glass lens base material heated to a predetermined temperature; and
a slide core portion advancing and retreating so as to hold peripheral side surface of said molding die from two directions.
(2) The glass lens molding device according to claim 1, characterized in that the slide core portion is embedded with a heater and a thermocouple.

3. Detailed Description of the Invention
Industrial Application Field
The present invention relates to a glass lens molding device such as, for example, a camera lens used for optical equipment.

Configuration of Conventional example and Problem thereof
Heretofore, as proposed, for example, in Japanese Utility Model Application No. 54-38126 as the glass lens molding device, a method of pressing and molding a glass lens base material heated to a predetermined temperature by a pair of molding dies has been used.

However, in case of such a device, respective molding dies have to be precisely assembled so that respective molding die axel centers forming the lens surfaces are precisely aligned, and at the same time, respective lens surfaces are prevented from being inclined, that is, the lens optical axes are aligned.

Further, since the pressing stroke of the molding die is fixed, unless the volume of a glass lens base material to be supplied is precisely stabilized, a lens thickness or a lens surface shape accuracy cannot be precisely obtained, and this leads to the inability of obtaining predetermined optical performance such as a focal length.

Further, when the volume of the glass lens base material to be supplied is made larger than the volume necessary for the molded lens, even if the lens thickness and the lens surface

shape are obtained as expected, an excessive lens base material is protruded in the outer peripheral direction of a molding die, so that a centering and edging process is required to make an lens outer diameter constant after the lens is molded. The centering and edging process requires many operation-man hours and invites cost-increase, and moreover, it is at high risk of impairing the lens surfaces in the operation process, and therefore, is not so preferable.

Object of the Invention

The present invention is to solve the above described conventional defect, and an object of the invention is to provide a glass lens molding device which permits a fluctuation of the volume of a lens base material to be supplied in a wide range, and at the same time, dispenses with the centering and edging operation after the lens is molded and desirably obtains the lens shape accuracy and the lens optical axis.

Configuration of the Invention

To achieve the above described object, the glass lens molding device of the present invention includes a pair of molding dies for pressing and molding a glass lens base material heated to a predetermined temperature, and a slide core portion advancing and retreating so as to hold a columnar side surface periphery of the molding die from two directions.

Description of Embodiments

Hereinafter, embodiments of the present invention will be described based on the drawings.

Figure 1 is a principal part sectional view showing a concept of the device of the present invention, and Figure 2 shows a top plan view of a molded glass lens molded by the device of the present invention.

In Figures 1 and 2, a lower die 1 and an upper die 2 form a predetermined ceramic material and the like into a columnar shape, and are disposed with axial centers made identical, and at the same time, one end surface of the respective dies has molding die surfaces 11 and 12 precisely constituting a predetermined molded lens surface shape in a form orthogonal to the die axis center, and the molding die surface is finished to

a predetermined mirror surface. In the embodiment of the present invention, the die surface shapes are made into concave surfaces respectively so as to obtain convex lenses.

With the lower die 1 in a fixed state, the upper die 2 is driven by a predetermined drive source, for example, an air or a hydraulic cylinder 6 and the like in the axial center directions of the upper die and the lower die, that is, in the optical axis direction (illustrated by the directions of arrows Z and Z′) of the molded glass lens 10 at a predetermined speed by a predetermined stroke amount.

Further, the upper die 2 and the lower die 1 are predeterminedly embedded with a heater for predeterminedly heating the glass lens base material supplied to a molding die surface, for example, such as a cartridge heater, and thermocouples for detecting the temperature. (unillustrated) Further, the outer diameter size of the columnar portion of the upper die 2 is configured to be larger by a predetermined amount than the effective diameter size of the molded glass lens 10, and the outer diameter size of the columnar portion of the lower die 1 is configured to be the same as the outer diameter size of the molded glass lens 10, and larger by the predetermined amount than that of the upper die 2. When the upper die 2 and the lower die 1 press and mold the glass lens base material into a predetermined lens size, bisected type slice core portions 3R and 3L made of ceramics members and the like are preconfigured to advance and retreat respectively in the directions of arrows X and X′ by a predetermined drive source, for example, means such as air cylinders 4 and 4, thereby to predeterminedly abut on both of the columnar side surfaces of the upper die 2 and the lower die 1, that is, as shown by the two-dot chain line in Figure 2, to besiege and hold the columnar side surfaces of the upper and lower dies.

It is to be noted that the slide core portion is also predeterminedly embedded with the cartridge heater and the thermocouples for keeping the glass lens base material at a predetermined temperature. (unillustrated) In a state in which the slide core portions 3R and 3L are predeterminedly abutted on the upper and lower dies 2 and 1, in addition to the volume having the same lens surface shape, lens thickness, and outer diameter size as the ideally shaped lens 20 shown in Figure 6, a

circular space portion 5A having a predetermined depth size and having the same outer diameter as the ideal lens 20 is formed on the outer edge portion situated outward from the effective diameter of the ideal lens 20 as shown by the hutching shape of Figure 5, and moreover, on the lens surface side formed by the molding die surface 12 of the upper die 2. The volume of the circular space portion 5A is formed in the predetermined size in consideration of the range of the volume fluctuation of the glass lens base material supplied to the molding die. Consequently, it should be appreciated that the volume of the glass lens base material supplied to the molding die surface 11 of the lower die 1 becomes a volume slightly reduced by a predetermined amount from "an ideal lens volume + a circular space portion volume".

That is, this volume is limited to the range not exceeding the volume of the space portion besieged and formed by the molding die surface 12 at the time when the upper die 2 has reached a bottom dead center position, the molding die surface 11 of the lower die 1, and the slide core portions 3R and 3L advanced and abutted on the columnar surfaces of the upper and lower dies 2 and 1. It is to be noted that a shape of the glass lens base material may use any supply shape such as a ball, a rectangular solid, and a disc.

Next, a process of molding a desired molded glass lens by using the glass lens molding device thus configured will be described.

In Figure 1, first, the slide core portions 3R and 3L are retreated to the predetermined positions in the directions of the arrows X', and at the same time, the upper die 2 is also lifted to the predetermined position in the direction of the arrow X'. In this state, the spherical or rectangular solid glass lens base material of a predetermined amount heated to a predetermined softening temperature is supplied and ingested to the molding die surface 11 of the lower die 1.

After that, the slide core portions 3R and 3L are advanced, and are predeterminedly abutted on the columnar side surface of the lower die 1. Subsequently, the upper die 2 is lowered to the predetermined position, so that the glass lens base material is pressed and molded, thereby the predetermined convex molded glass lens 10 is molded. In detail, the glass lens base material

is heated by a preheating process and a pair of upper and lower dies 2 and 1, and is pressed while maintaining a softening state, so that, by the pressing force of the upper die 2, the glass lens base material flows along the shapes of the molding die surfaces 11 and 12 of the upper and lower dies 2 and 1, and in the first place, forms a lens effective diameter portion, and subsequently, flows also on the lens outer edge portion of the outer periphery from the lens effective diameter portion, thereby to fill the circular space portion 5A.

As a result, the desired lens surfaces 11 and 12 and the lens outer diameter portion are predeterminedly formed. Since a measurement fluctuation of the glass lens base material to be supplied is absorbed as a fluctuation of the glass amount flowing into the circular space portion 5A provided at the lens outer edge portion and the molding die surface 12 side of upper die 1, the accuracy of respective lens surface shapes and the accuracy of respective lens outer shape sizes of the lens effective diameter portion are not affected by the measurement fluctuation, and are always kept at high accuracy with the lens molded to a fixed shape.

After that, the molded glass lens passes through each process of cooling and solidification, and after that, the upper die 2 and the slide core portions 3R and 3L are lifted and retreated respectively, so that the convex lens shown in Figure 2 is completed. Here, the relationship among the preheating temperature of the glass lens base material, the heating temperature of the upper and lower dies, the heating time, the pressuring force of the upper die, the bottom dead center position of the upper die, the circular space portion volume, and the like is important, and the predetermined conditions have to be set according to the target lens shape size, the type of the glass material to be used, and the like.

Figure 3 is a principal part sectional view showing another embodiment of the present invention, and Figure 4 shows a top plan view of the molded glass lens molded by the device of Figure 3. Configuration points different from Figure 1 are that (1) the slide core portions 3R′ and 3L′ predeterminedly abut only on the columnar surface sides of the upper die 2′, and (2) in place of the circular space portion, concave portion spaces 5B at a plurality of places (four places in the figure) are

provided on the lens surface side of the lens outer edge portion situated outward from the lens effective diameter portion, and the measurement fluctuation of the glass lens base material can be absorbed by the space concave portions. Further, the advantage of obtaining the lens surface shape accuracy, the lens outer diameter size and the like with a high degree of accuracy, and the advantage of dispensing with the centering and edging process after the lens are molded can be obtained similarly to the case of Figure 1.

In the above described embodiment, the shapes and the sizes of the circular space portion and the concave portion space portion disposed at the lens surface side may be optionally set, and the means for driving the upper die and the slide core portions are also not limited to the cylinder, but any means such as a cam may be used. Further, out of a pair of molding dies, there is no need to fix the lower die, but both of the dies may be driven so as to perform the molding.

Advantages of the Invention

As described above, the present invention presses and molds the glass lens base material slightly reduced from "the ideal lens volume + the circular space portion volume", and absorbs the measurement fluctuation of the glass lens base material as a fluctuation of the glass amount flowing into the circular space portion provided on the lens surface side of the lens outer edge portion, so that the accuracy of the lens surface shape, the lens outer diameter size, and the like can be formed with a high degree of accuracy, thereby to dispense with the centering and edging process also after the molding. Further, additional advantages are afforded in that, by the slide core portions abutting on the columnar side surfaces of the upper and lower dies, the axial centers of the upper and lower dies are aligned with a high degree of accuracy, and at the same time, the molded glass lens can be held in a state in which the inclination of the lens surfaces is not generated, thereby to realize the molded glass lens having an extremely high degree of accuracy.

4. Brief Description of the Drawings

Figure 1 is a principal part sectional view showing a concept of one embodiment of the device of the present invention.

Figure 2 is a top plan view of the glass lens molded by the device of Figure 1. Figure 3 is a principal part sectional view showing a concept of another embodiment of the device of the present invention. Figure 4 is a top plan view of the glass lens molded by the device of Figure 3. Figure 5 is a sectional view of a circular space portion used for description of the present invention. Figure 6 shows a sectional view of an ideal lens.

1, 1'... Lower die, 2, 2' ... Upper die, 3R, 3R', 3L, 3L' ... Slide core portion, 4, 6 ... Cylinder, 5A ... Circular space portion, 5B ... Concave portion space, 10, 10' ... Molded lens, 11, 12 ... Molding die surface, 20 ... Ideal lens